AIRS Activities at NOAA/NESDIS

Chris Barnet
Mitch Goldberg

December 1, 2004

NOAA/NESDIS/STAR

We moved to the Airman's building across the street from the World Weather Building on Auth Road, Camp Springs

New phone: 301-316-5011

Topics Covered

- Cloud Clearing Risk Reduction Activities
  - Risk reduction w.r.t. a failure of AMSU
  - Improving cloud clearing: emissivity cross-talk issues.
- Trace Gas Products
  - Improved first guess states for carbon gases.
  - Product averaging functions.
- L2 issues.
  - Convergence in water and trace gas retrievals.
  - Cij
- Summary of NOAA/NESDIS AIRS Datasets
- Summary of recommendations for v5.0

Cloud Clearing Risk Reduction

Nick Nalli

Walter Wolf

Lihang Zhou

Collaboration with Mous Chahine,
Bob Knuteson, and Dave Tobin

Cloud Clearing Risk Reduction Options Currently Being Explored

- Operate CC from forecast model (AVN or GDAS)
  - Concept works (ASTM 3/30/04)
  - Recommend installation of option for v5, evaluate in frontal situations.
- Use a regression trained on cloud contaminated radiances.
  - Concept works (ASTM 3/30/04)
  - Minor code changes to allow a 2nd set of coef's
  - Recommend installation of option for v5.
- Use MODIS, convolved to AIRS FOV's
  - Use MODIS as a QA for AIRS CCR's (Mitch will discuss this)
  - MODIS/AIRS CCR regression is under study (Mitch will discuss this)
  - MODIS/AIRS CCR physical approach is in development.
- SW/LW iteration technique (a.k.a. IR cloud clearing).
  - Preliminary algorithm discussed (3/30/04) Concept needs development.
  - This approach has many applications for future sounders.
  - Will begin working out the details in FY05.

Cloud Clearing Risk Reduction Emissivity Issues

- Emissivity regression retrieval does not seem to be working well
  - Latest upgrades (4 surface types) is an improvement, but typically produces erroneous spectral structure over land, especially desert, snow, and ice, affecting ozone & water retrievals.
  - These occur in ≈ 10% of the cases.
  - We will investigate improving the training & surface type selection.
- Emissivity physical retrieval still has major problems.
  - Recent upgrades rely more on the regression for spectral shape.
  - It is now clear that Tskin and emissivity are not separated well.
- Three experiments are shown to illustrate the issue.

1. "d60" V4.0 emulation (2 _, 1 _)
2. "d61" uses NOAA REG + SVD to solve for 15 _ & 1 _
3. "d62" Does not NOAA Reg. Assume an emissivity value at one frequency and solves for relative emissivity

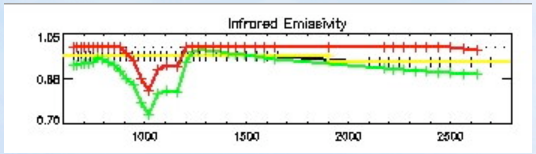
   Land: _(831 cm^{-1}) = 0.98

   Ocean: _(900 cm^{-1}) = Wu/Masuda

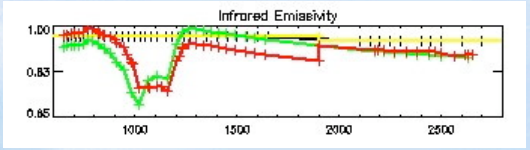
   Snow/Ice: _(960 cm^{-1}) = 0.999

Example of Desert Emissivity

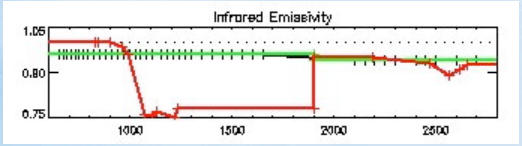
In v4.0 the regression produces spurious spectral emissivity structure, 2 function constraint cannot remove it

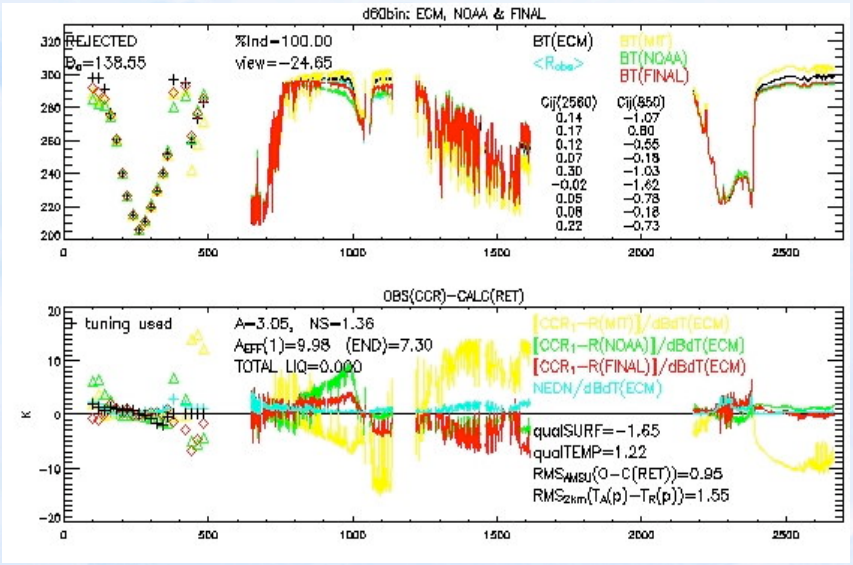


Increasing # of F's helps to correct _(_) & q(p)



Fixing e(852)=0.98 captures more structure, but currently fails in opaque regions.





There are many ideas to explore

- Continue work "direct" method of solving for emissivity.
  - Solving for Tskin using σ(_) continues to fail, especially in cloud clearing – but it should work.
  - Faill back: Can constrain emissivity at a given frequency.
  - Use AIRS physical to define surface type → regression?
- Experiment: Constrain IR surface brightness from clear masked MODIS radiances prior to 1st CCR.
  - Use MODIS to improve "direct" emissivity retrieval.
    - Chl. 32 (810-850 cm-1) over land
    - Chl. 31 (880-930 cm-1, but AIRS has a gap here) over ocean, snow, ice.
  - A number of experiments are planned to correct for sub-pixel surface variability (*i.e.*, use in error covariance), use of MODIS radiances for Tskin & emissivity first guess, MODIS+AIRS T(p), etc.

Trace Gas Products

CO: Collaboration w/ Wallace McMillin, Michele McCourt

CO_2: Mous Chahine, Eric Maddy, Xingpin Liu

collaboration with Randy Kawa, GSFC

collaboration with Daniel Jacobs, Harvard

collabortation with Scott Denning, CO State

CH_4: Xiaozhen Xiong

O_3: collaboration with Mike Newchurch & Bill Irion

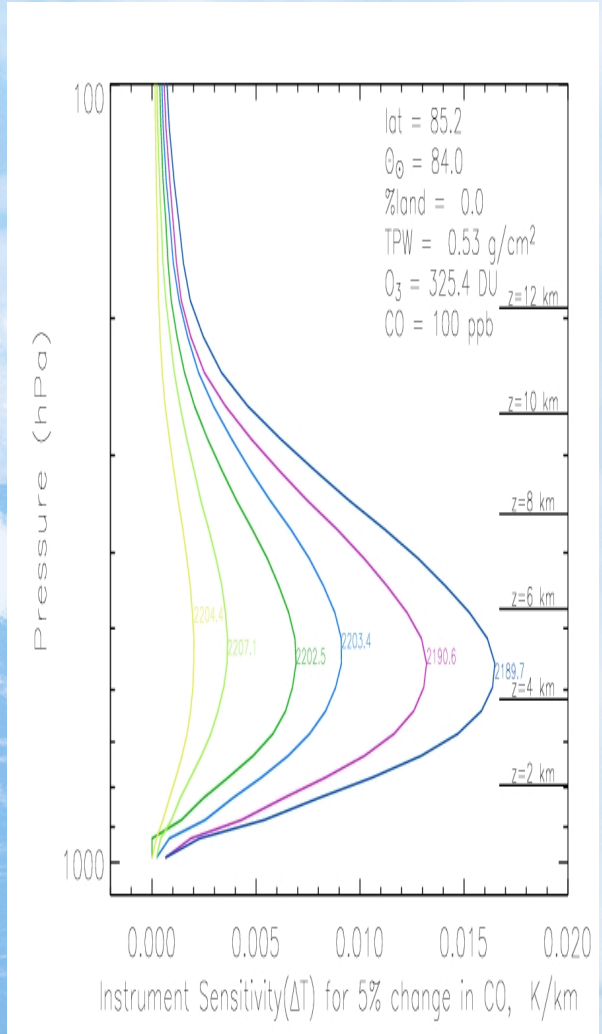
UTH: collaboration with Dave Whiteman & Antonia Gambacorta

Trace Gas Weighting Functions

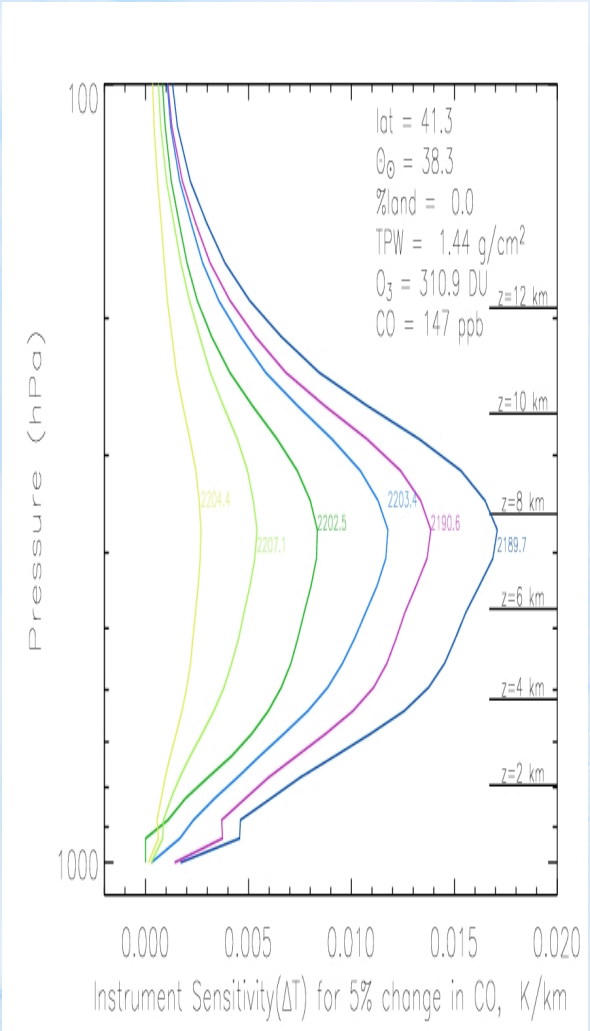
- Averaging functions are a necessary component of the trace gas product.
  - Modelers need to know the altitude range of our measurements.
  - Averaging function is a function of the gas concentration, temperature profile, and moisture profile, therefore, it is case dependent.
- Off-line system has been modified to output the information content analysis.
- Detailed comparison with ozone sondes & CMDL CO measurements is in work.
  - Initial comparisons look reasonable for the sparse measurements we have.

Example: AIRS CO Kernel Functions are sensitive to $H_2O(p)$, T(p) & CO(p).

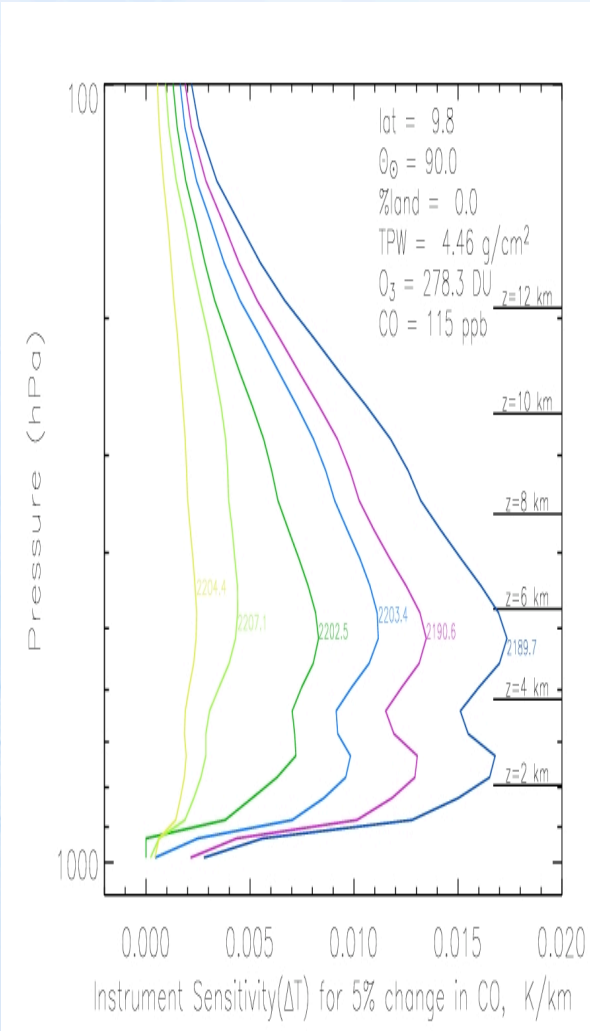
Polar



Mid-Latitude



Tropical



Ozone-sonde matchups (collaboration w/ Newchurch & Irion

V4.0 has 7 ozone functions, the bottom 2 covering 140-300 & 300-1000 mb.

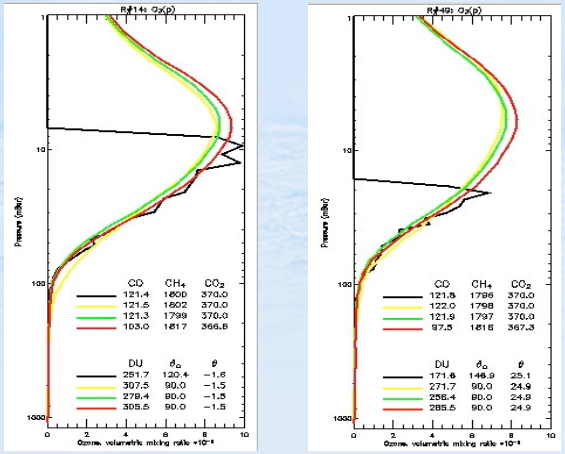
P range	A(1)	A(2)
7-20	34	29
20-50	61	56
50-70	46	44
70-100	25	25
100-140	25	27
140-300	**45**	**50**
300-surf	**40**	**41**

More functions at bottom have more realistic weighting

140-210	22	24
210-300	29	25
300-600	34	38
600-surf	18	17

This issue makes ozone more sensitive to emissivity errors.

Case # 1 2

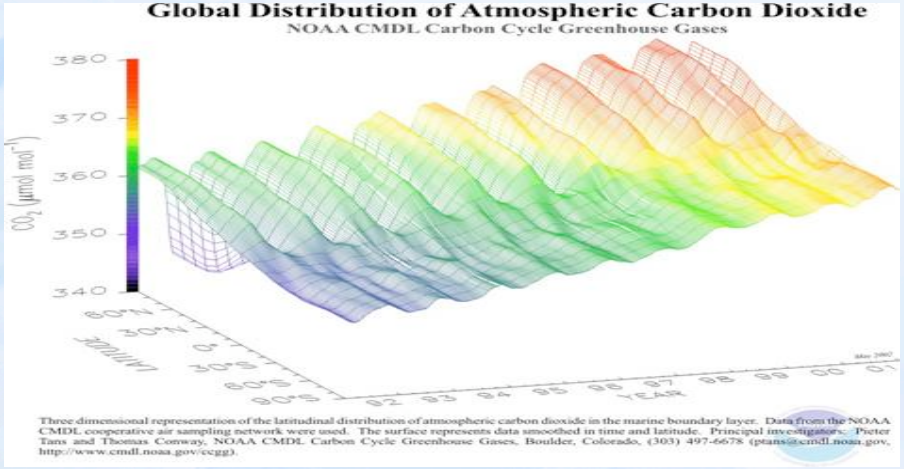


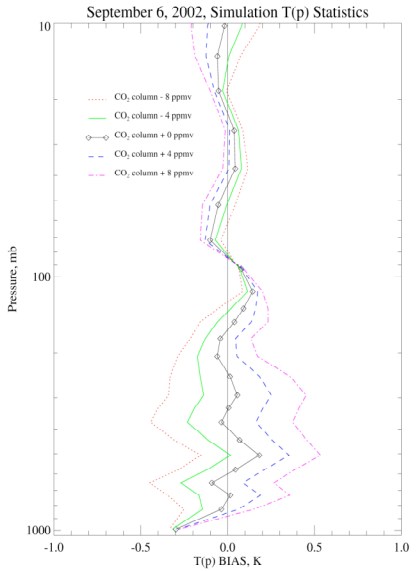
Atmospheric Trace Gases in v5.0

- Add information content output in L2 file for all trace gases.
- Minor changes in v5.0 to O3 namelists.
  - More functions to improve lower boundary ozone
- Minor changes in v5.0 to CO namelists
  - More functions to defined weighting function
  - Use constant mixing ratio first guess (same as MOPITT)
  - Add additional channels.
- Minor changes in v5.0 to CH4 namelists.
- CO2 retrieval needs development. We will inter-compare approaches.
  - Install a CO2 first guess to eliminate T(p) biases.
  - Physical Approaches
    - SVD algorithm (Eric)
    - Direct derivative algorithm (Mous)
  - Model approach (Larrabee)
  - Regression approach (Eric)
  - Collaboration with William Blackwell On NN approach

We should install a mid-tropospheric climatology for CO_2 in v5.0

- +2 ppmv/yr induces ≈ -0.1 K/yr in mid-troposphere T(p) bias.
- +/- 6 ppmv seasonal signal induces a -/+ 0.3 K seasonal T(p) bias.
- Need to assess mid-troposphere CO_2 climatology and install in v5.0.
  - Use operational sonde database to determine CO_2(time,latitude)
  - Use CMDL measurements & transport model to convert NOAA/CMDL surface measurements to the mid-troposphere (we expect phase shift & reduced amplitude).





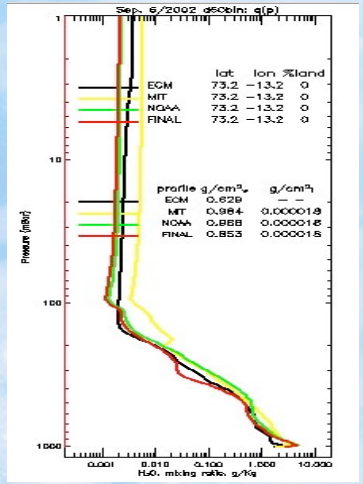
L2 Issues

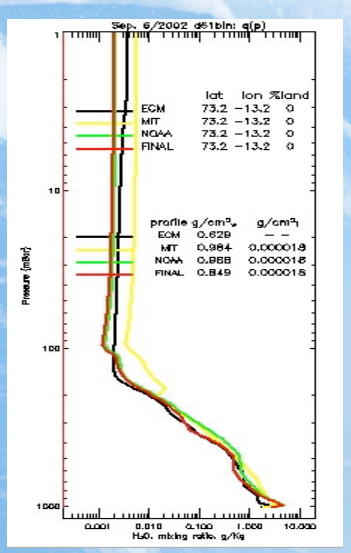
Eric Maddy

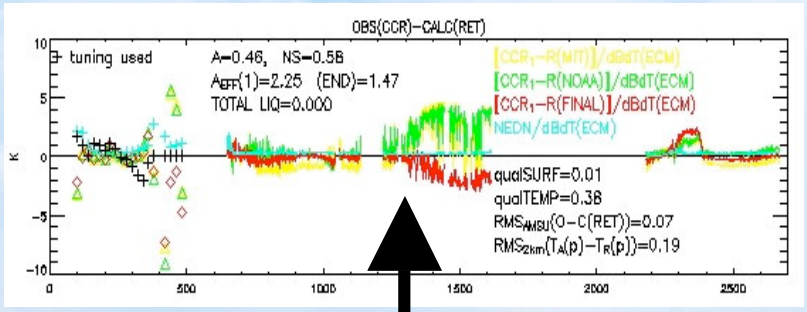
Lihang Zhou

Collaboration with Allen Huang, UWisc.

V4.0 moisture fails to converge ≈ 1% the time

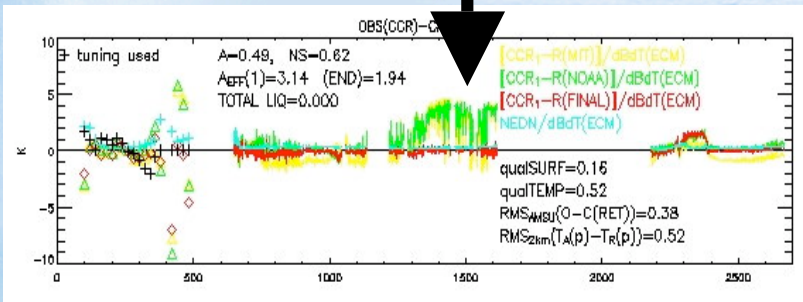






QA (qualwatr) can reject these; however, this test is not in the v4.0 QA

But a simple fix can produce a good water retrieval without rejection.



This happens when regression gives a poor answer and physical makes too large a change and then terminates due to slow convergence

<u>Recommend</u>

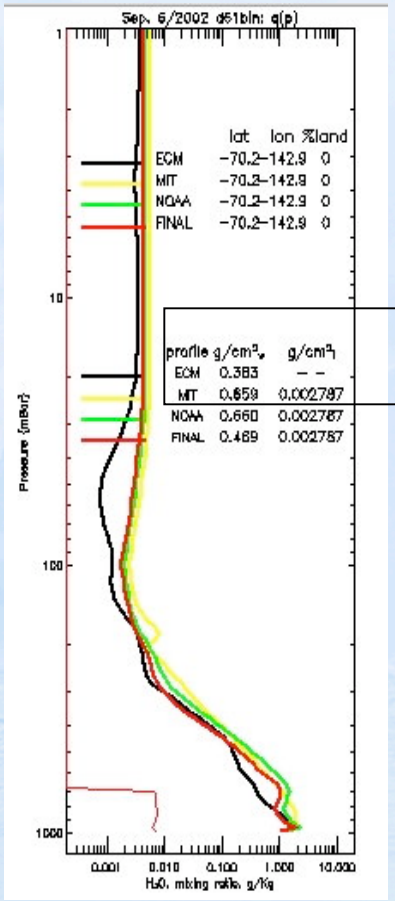
Adding qualwatr to rejection criteria.

Modification of 75% convergence test to occur after iter=3.

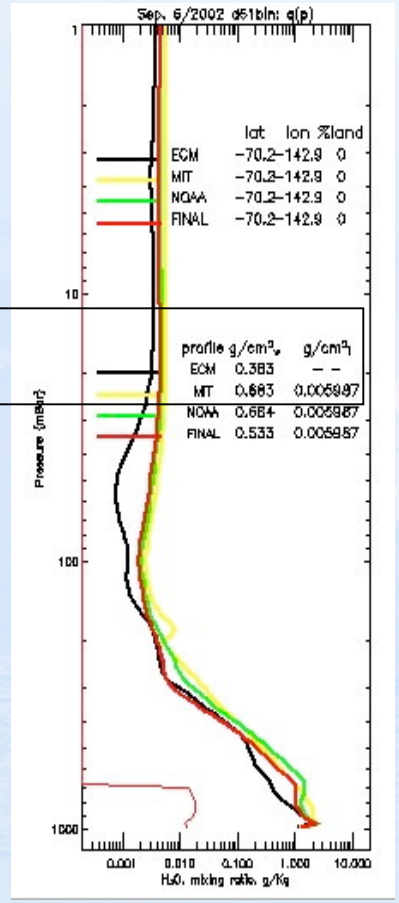
89 GHz tuning

- In V4.0 empirical tuning is used for AMSU 1-14, but not AMSU-15.
- Empirical tuning coefficient for Chl.15 is 3-5 K
- Theoretical considerations (Phil, Bjorn) suggest this channel should not be tuned.
- Not tuning AMSU Ch.15 has a impact liquid water (x 2) and water vapor (5%).
- A greater concern is that the tuning is inconsistent with the 22,31,50 GHz window.
- Recommend we fix empirical tuning to agree with expectations and consistently tune all channels

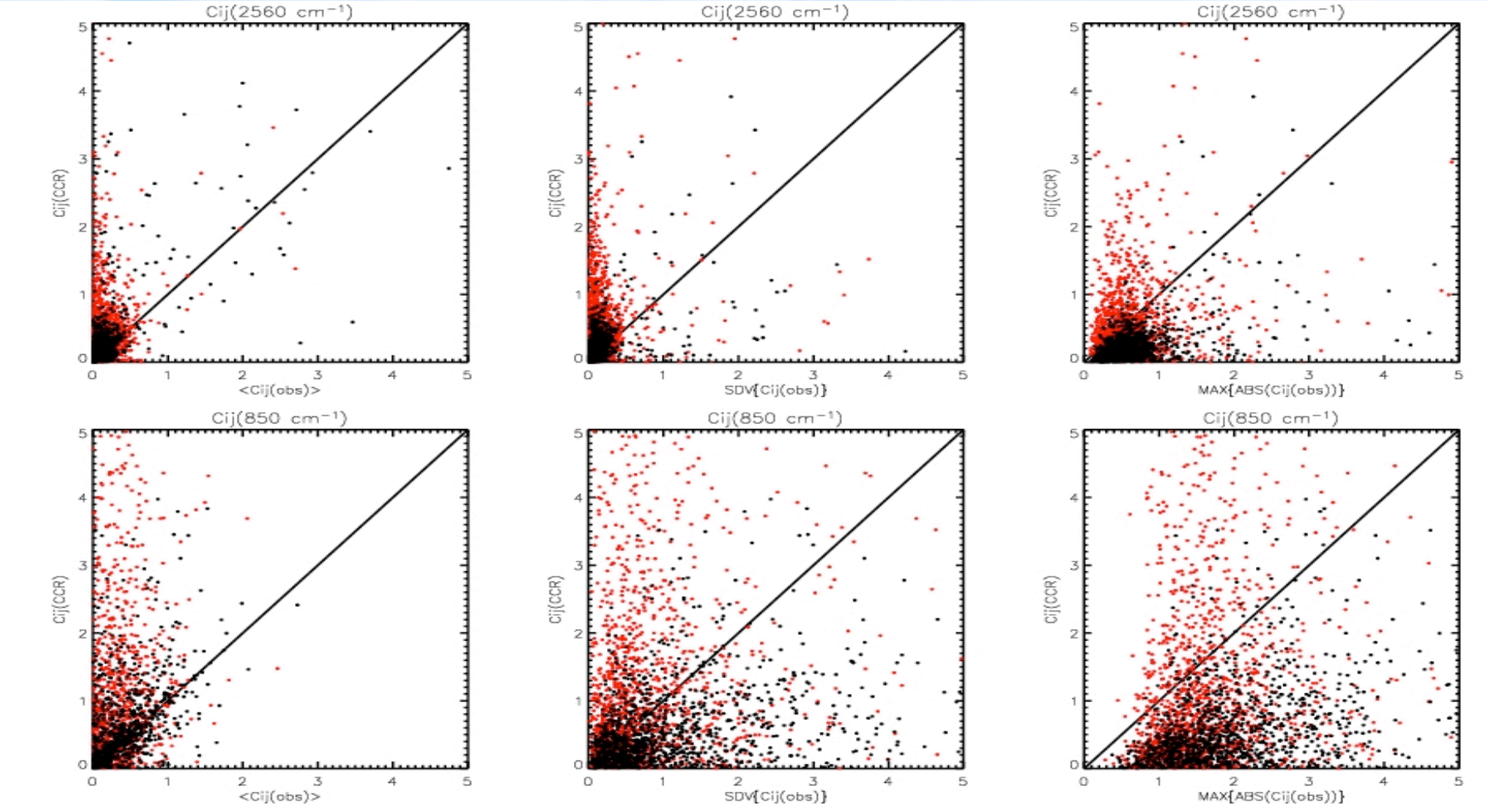
With tuning



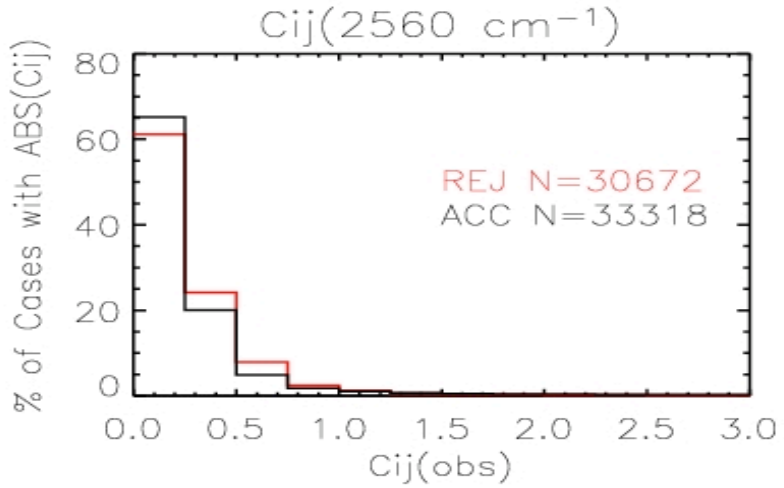
Without tuning

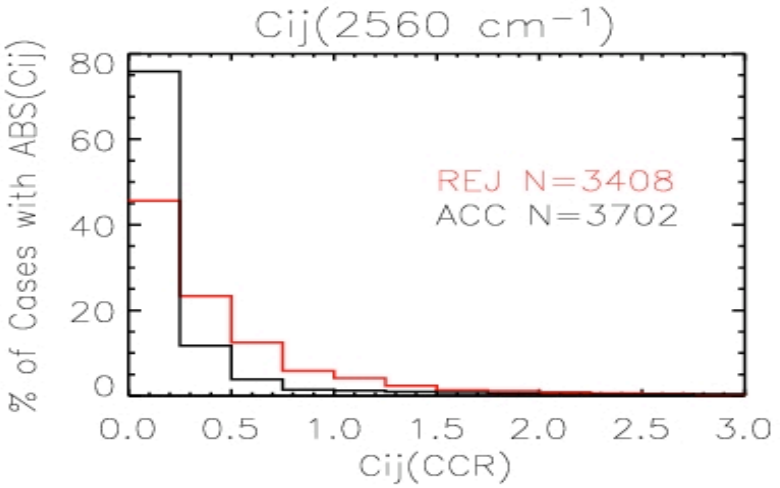


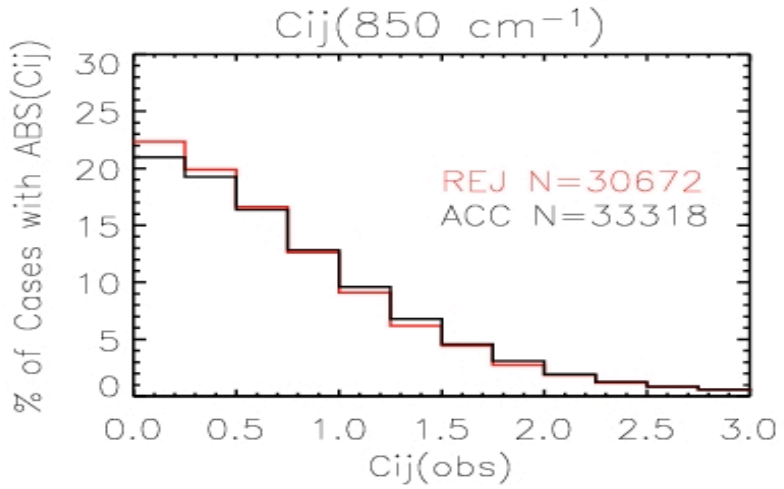
CCR Cij versus AIRS Cij
<9 FOV's> σ(9 FOV) MAX(9 FOV)

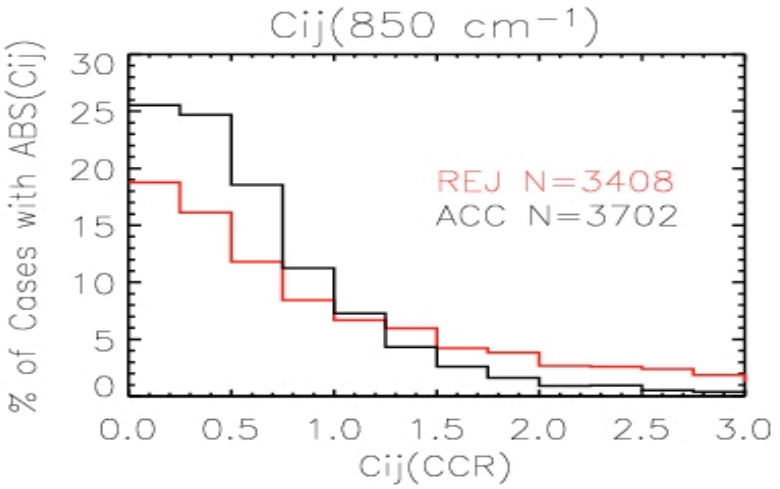


Histogram of Cij
Observed 9 FOV's CCR (FOR)

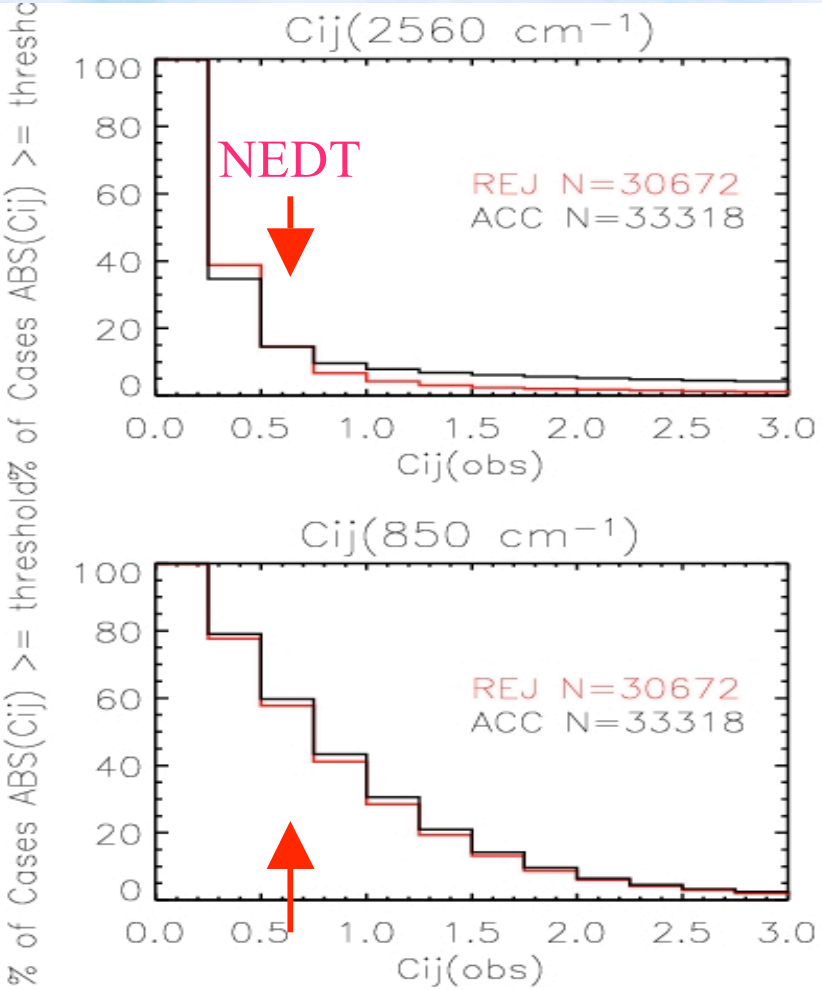


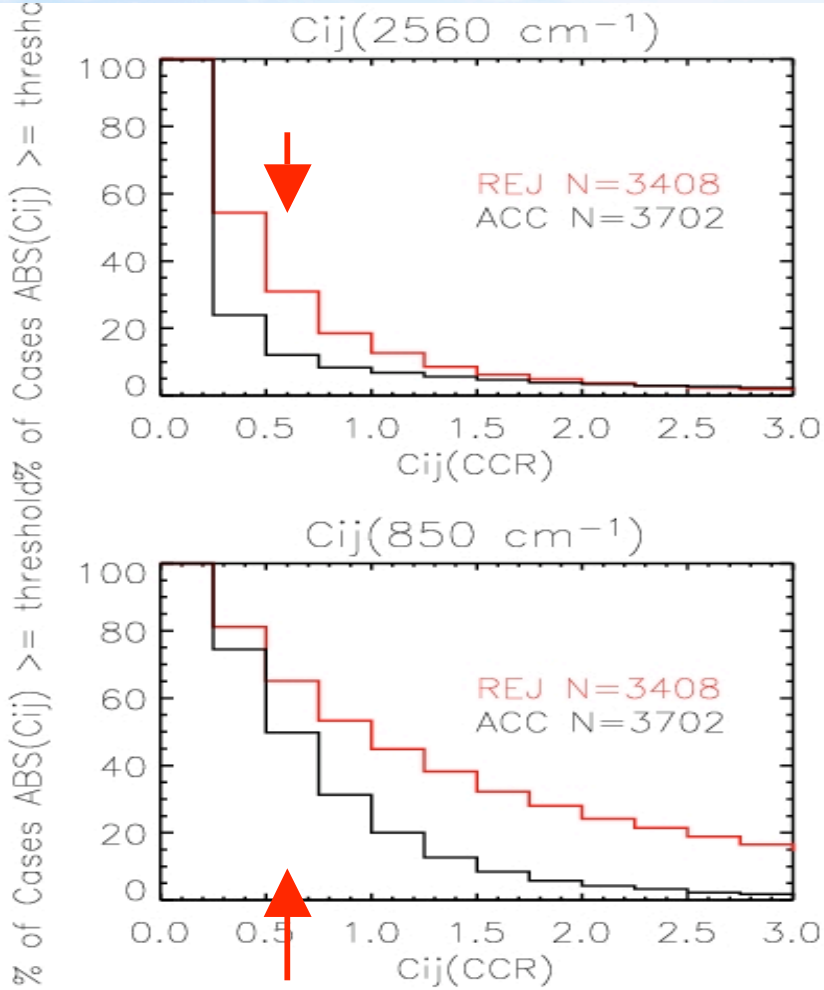




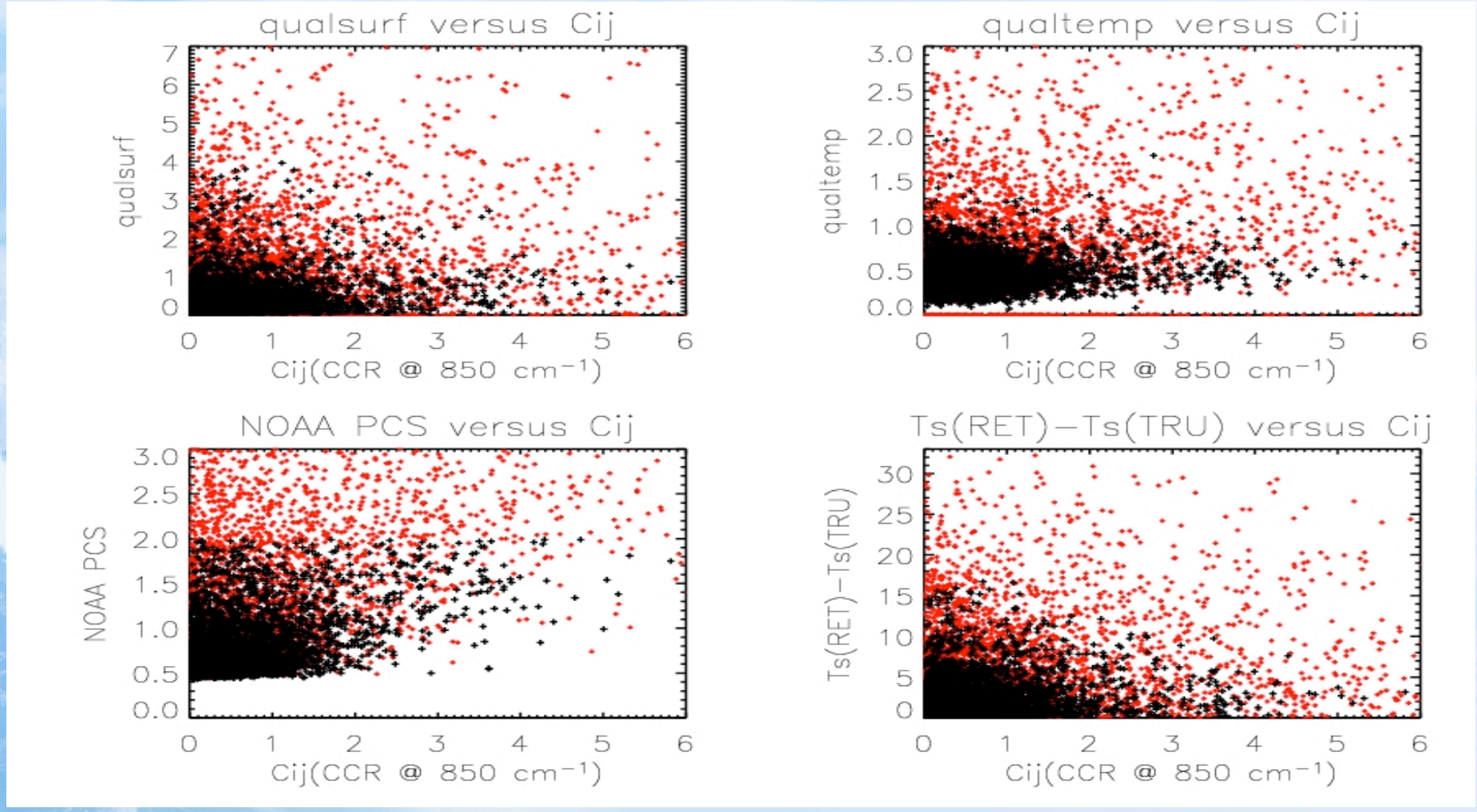


% of cases exceeding Cij threshold Observed 9 FOV's CCR (FOR)





Product QA have little dependence on Cij of CCR's

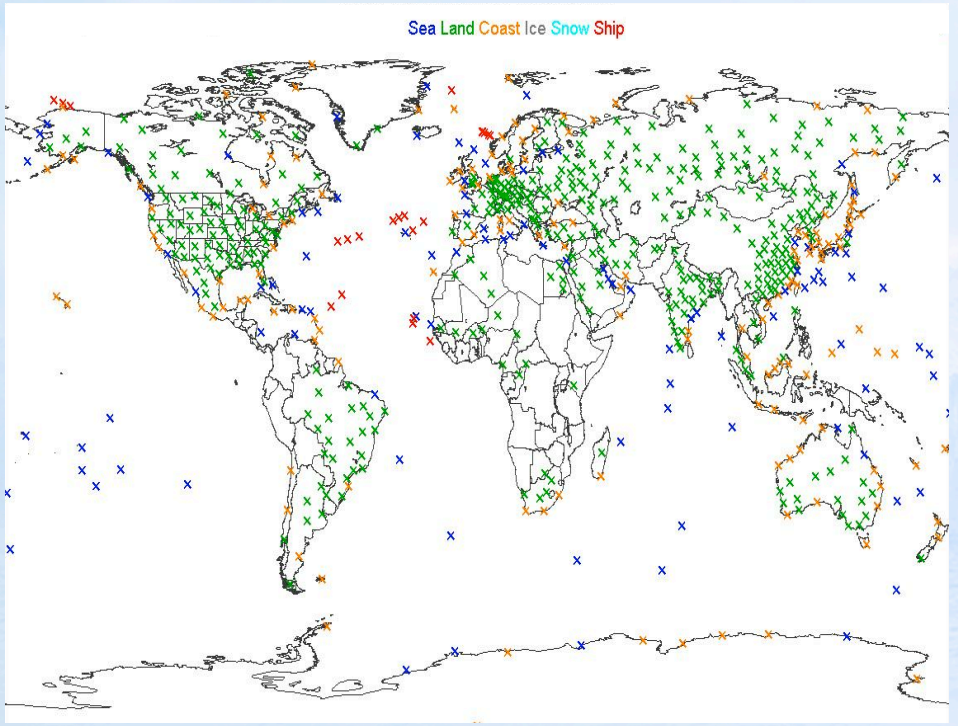


Datasets Used for Analysis

- Individual Granules & Concatenated Global Files (G401's, G422's)
- Operational Sondes: (Murty Divakarla)
  - ≈. 100/day, Nov. 2002 – present
  - Will use to study biases, produce regression coefficients
- Global 3°x3° "Re-processing" Grids: (Lihang Zhou, Walter Wolf)
  - 61x120 cases, asending and descending orbits, June 2003 – present.
  - MODIS convolved gridded product started in Nov. 2004.
- Clear **single** FOV's (collaboration with Larrabee Strow)
  - ≈ 20,000/day, Oct. 2002 to present, ≈ 45% are accepted
- Simulation: (Eric Maddy)
  - G401's, G422's for focus days & 3°x3° grids

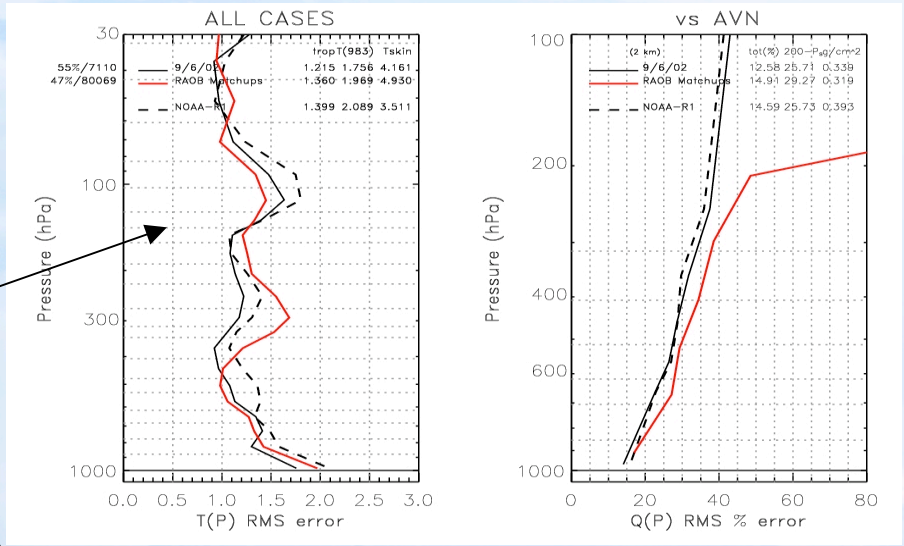
Selection of Operational Sondes

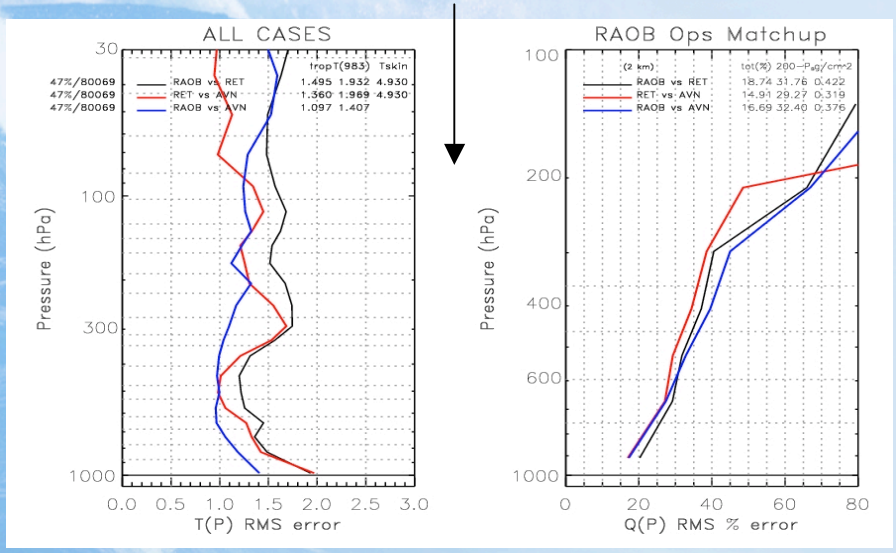
- Approx. 900 sites/sondes
  - 80000 cases within 100 km ± 3 h of AIRS Obs. 9/2002 to 9/2004
  - 30% of those within within 50 km ± 1 hour
- Operation sondes require QA
  - ≈ 60% are “good”
- ≈ 6% over open ocean

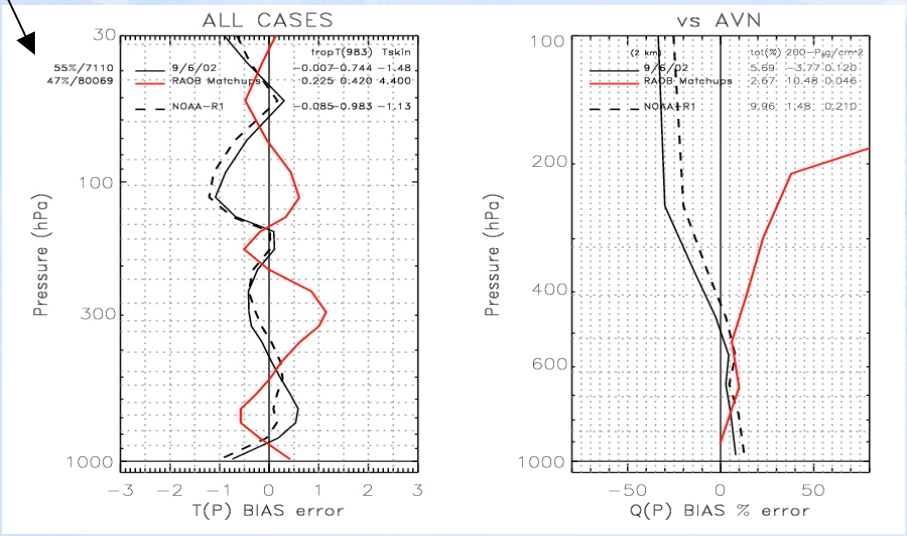


Preliminary comparisons (v3.7) are similar to single day statistics

- Preliminary system is running.
- Comparisons vs ECMWF is in work.
- Comparison of RET-AVN is shown for 9/6/02 (Black) & RAOB dataset (Red). (NOTE: sign switch on bias)
- RAOB-RET (Black) , AVN-RET (Red) and RAOB-AVN (Blue) is shown below.







Summary of Issues for v5.0

	V4.0	recommendation
Water convergence	QA Not tested 75% test on iter >= 2	QA & code mod to test on iter >= 4
All "75%" convergence	Tested on iter >= 2	code mod to test on (iter >= 4, reject if fails
Ozone Functions	7	10 or more
Ensemble error & null estimates.	Very low values for null estimate	Increase value
CO2 first guess	370 ppm	CO2(time,latitude,p)
CO first guess	RTA reference profile, Fixed CD in PGE	Use MOPITT fixed mixing ratio profile, CO(p)
CO,CH4 rets	off	Turn them on in non-interactive mode

Summary of Issues for v5.0

	V4.0	recommendation
T(p) AMSU Chl's	Not used in coupled ret	Use them, they impact residual tests & T(p) bias
Regression weight when CCR have high error.	Used 100%	Blend with AVN 300-surf w/ Aeff(1) as criteria or reject these cases.
NOAA synthetic emissivity regression	Spectral Shape is believed.	Don't use unless a better approach is found.
SVD emissivity retrieval	Severely Constrained	Investigate & implement other approach(es)
89 GHz tuning	Tuning Set to Zero	Fix empirical tuning or use empirical tuning value.
High Cij FOV's	Uses all FOV's	Test rejection of FOV's with poor Cij